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Defining road and rail vehicles with a low environmental footprint

L.D. Poulikakos [a,*], R.M. Mayer [b], K. Heutschi [a], P. Soltic [a], A. Lees [c], H. Van Loo [d]

[a]*Empa, Swiss Federal Laboratories for Material Science and Technology, Überlandstrasse 129, CH-8600 Dübendorf, Switzerland*
[b]*Sciotech Projects, Engineering Building, University of Reading, Reading RG6 6AY, United Kingdom,*
[c]*Q-Free TDC Systems, 30 Lynx Crescent, Weston-super-Mare, North Somerset, BS24 9BP, United kingdom*
[d] *Corner Stone International, Via ai Crott 5, CH-6702 Claro, Switzerland*

Abstract

Determining the environmental footprint of heavy vehicles and limiting this footprint is a complex task that requires the involvement of all stakeholders. The ongoing Ecovehicle project that is summarized in this paper demonstrates that the footprint of heavy vehicles can be quantified. It was shown that in each vehicle category there are those with a high total footprint indicating a large difference between vehicles in every category and a high potential for improvement. A recent study in Switzerland has calculated the external costs of the four modes of transport, to be over CHF 9’400 million for 2010. It was shown that most of these costs are not recovered. Considering the external cost of freight transport, the report shows that the freight traffic cost 7.1 Rp/tkm of which 4.4 Rp/tkm was internalized through the heavy vehicle fee (LSVA), implying in turn that 2.7 Rp/tkm was not recovered by the fee. The external cost of rail on the other hand was 2.8 Rp/tkm, air freight 7.6 Rp/tkm whereas the cost of ship transport on the Rhein was 0.5 Rp/tkm. Promoting ecofriendly vehicles however requires the introduction of incentives, and bonus-malus systems Europe wide. Data quality is of particular importance when comparing the environmental effects in different European countries. The data reported here, the external costs as well as the incentives discussed are from Switzerland however, the general conclusions can be extended to all modes of transport and other countries as the results are universal.

Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)

Keywords: Transport Footprint; noise; WIM; pollutants; bonus/malus

* Corresponding author. Tel.: Tel +41-58-765-4479
E-mail address: lily.poulikakos@empa.ch

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1. Introduction

Road and rail infrastructure comprise an important asset of any country and a vital contributor to its economy and society. The ongoing Eureka European cooperative project Ecovehicle E!7219 (www.eureka.be) addresses various options to reduce the impact of road and rail vehicles on the infrastructure and the environment.

The interaction between a vehicle and its infrastructure be it road or rail is very non-linear and can increase up to the 4th power of the axle load for road vehicles. For rail vehicles operating on poorly aligned track, unloading on one wheel can lead to overloading up to 60%. With improved technical standards it is a timely topic to discuss options to reduce this disproportionate damage to the infrastructure considering also policy options. Many countries have policy in place to limit such damage through track access or road usage charging. In the light of ever increasing volumes of transit traffic, it is therefore important to reduce damage to the infrastructure and that of the infrastructure to the vehicle by minimizing the static and dynamic interaction between these two components. Noise generation is one of the most important factors limiting the capacity of the EU's transport. This has been the subject of the EU's noise directive (2002/49/EC) and also the EU's greening transport package (MEMO/08/492 08/07/2008) in which the idea of a bonus/malus incentive was described. As noise arises from the interaction of a wheel/tyre with its infrastructure, this paper will review cost effective solutions for both road and rail modes and the role of regulation and incentives. To initiate the transformation to low noise rail vehicles, a bonus system has been introduced in some countries for vehicles equipped with low noise (composite) brake blocks. In addition a further bonus has been introduced for braking on discs rather than on the wheel tread. Options for a bonus/malus system for quiet road vehicles will be discussed subsequently.

There is a need for stabilizing the world's carbon emissions by 2020 and then to decrease these by a minimum of 3% each year up to at least 2100 (5th IPCC assessment report). In addition in many cities and along traffic corridors, WHO guidelines are exceeded for pollutants like PM10, SO_x and NO_x. Pollutant emissions of heavy duty road vehicles were drastically reduced in the last years which will lead to reduced pollutant emissions as these vehicles are penetrating the fleet due to the introduction of low emission engines. The political focus will therefore change from local pollutants to the globally relevant greenhouse gas emissions. The reduction in gaseous emissions will be reviewed against a background of rising energy prices, increased societal concern about pollution, EU regulation and legislation and industrial initiatives and what options exist for further reductions in emissions.

A case study from Switzerland will be presented where in situ measurements have shown that no vehicle class is particularly damaging to the road or the environment. It was shown that in every vehicle category there are those with a low and those with a high overall footprint. Therefore the need for incentives to encourage the vehicle with a low overall footprint and discourage those with a high footprint is paramount. The data reported here, the external costs as well as the incentives discussed are primarily from Switzerland however, the general conclusions can be extended to all modes of transport and other countries as the results are universal.

Nomenclature

WIM	weight-in-motion
LSVA	Swiss heavy vehicle fee (HVF)
WHO	World Health Organization
HDV	Heavy duty vehicles

2. Cooperative project Ecovehicle

The European cooperative project Ecovehicle (E!7219) is a follow up of Eureka Logchain Footprint (E!2486) that has been successful in developing methods to identify environmentally friendly vehicles for road and rail transport modes (www.eureka.be, Poulikakos et al. 2009, 2010, 2013, Mayer et al, 2012). The footprint of vehicles was defined as dynamic load, noise, pollutant emissions and vibrations. Footprint monitoring sites were installed in Switzerland and other partner countries in order to measure the footprint of passing vehicles using innovative techniques. It was shown that parameters that are currently controlled and their reduction encouraged such as gaseous emissions, axle loads and gross weight are for the most part below or close to acceptable limits. However other important parameters such as tyre pressure and noise remain to be higher than acceptable limits. Furthermore, it was shown that there was no systematic dependence of the noise emissions on the Euro emissions classes for each Swiss 10 category. This shows that the vehicles with the newer Euro-V emissions classes are not necessarily less noisy. It was concluded that new instruments have to be developed in order to encourage vehicles with a low noise footprint. In addition a noise emission model was developed, allowing the individual footprint of a vehicle to be estimated from parameters that are known or observable. Furthermore, 2 models were proposed for the calculation of the total footprint of heavy vehicles. With the help of the total footprint models developed, heavy duty vehicles could be evaluated using a holistic approach taking into account a combination of all their individual footprints. The results show that in almost every category there are vehicles with a very high combined footprint.

The Ecovehicle (E!7219) project has the following global aims:

- to increase the safety of vehicles operating on road or track by making measurements in service and informing the operator
- to develop an environmental label for road and rail vehicles
- to relate impacts to costs for individual vehicles

3. Combined environmental footprint of vehicles

In previous studies (Poulikakos et al 2009, 2010, 2013, Mayer et al 2012) it was shown that it is possible to obtain a holistic impression of the environmental footprint of heavy vehicles and methods were developed to combine these footprints in order to derive the combined footprint of individual road vehicles for all SWISS 10 vehicle classes. A sample of the results combining axle load, noise and gaseous emissions data from about 100’000 heavy vehicles on the A1 motorway in Switzerland is shown in Fig. 1. The results are shown in the form of a box plot for each vehicle category, with the median shown as a line, 50% of data is in the box and outliers are indicated with a +. The vehicle categories go from 1 (buses) to 10 (articulated vehicles) which are the largest. This method shows that although the median footprint for each category is around zero, in every category there are vehicles with a high total footprint indicating a large difference between vehicles in every category and at the same time demonstrating a high potential for improvement.

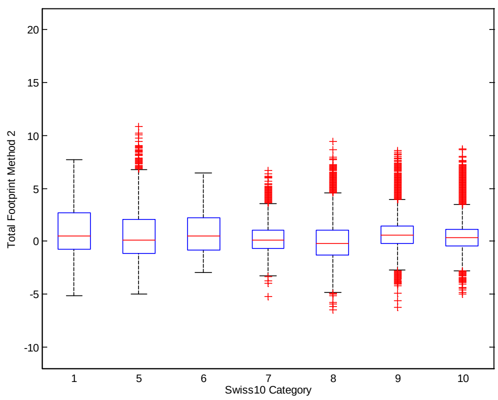


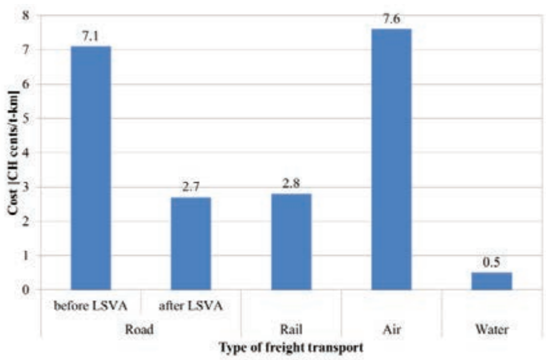
Fig. 1. Box plot showing distribution of total footprint of Swiss 10 vehicle categories (Poulikakos et al 2013b).

4. External costs of transport

A recent study by the Swiss federal office for spatial development has documented the external costs of transport (Ecoplan, Infras, 2014). The study calculates the external and social (national economic) environmental, accident and health-related effects of transport in Switzerland in 2010. In doing so, previous calculations relating to road and rail transport are subject to a methodological review, and recalculated for 2010 using fully updated data sources for the following 12 cost areas: air pollution-related damage to health, damage to buildings, crop shortfalls, forest degradation, loss of biodiversity, noise, climate change, nature and the landscape, soil degradation, upstream and downstream processes, accidents, and additional costs in urban areas. In these cost categories, the external costs of air and waterborne transport in Switzerland are also calculated for the first time, and the road transport section of the study has been extended to include non-motorized transport (pedestrian and cycle traffic). The positive effects on health of the physical exercise involved in non-motorized transport are also quantified. Aggregated across the four modes of transport, total external costs come to over CHF 9’400 million for 2010. At CHF 5’500 million, private motorized road transport is the main originator of these external costs, followed by road freight transport at CHF 100 million (a share of the HVF (LSVA) has been factored in as an internalization measure), and by public road transport, with a contribution of CHF 190 million. Air transport resulted in external costs of CHF 920 million, while rail transport accounts for CHF 740 million. Waterborne transport generated external costs of CHF 57 million. In addition to external costs of CHF 900 million, non-motorized transport generates external health benefits worth CHF 1’300 million. The significant differences in distances travelled using the individual modes of transport must be remembered when comparing these absolute figures. Considerably more person and tonne kilometers are travelled by road than by other modes of transport, while figures for waterborne transport are much lower.

Considering the external costs in terms of transported tonnes, the report shows that the freight traffic cost 7.1 Rp/tkm of which 4.4 Rp/tkm was internalized through the heavy vehicle fee (LSVA), implying in turn that 2.7 Rp/tkm was not recovered by the fee (Fig. 2). The external cost of rail on the other hand was 2.8 Rp/tkm, air freight 7.6 Rp/tkm whereas the cost of ship transport on the Rhein was 0.5 Rp/tkm.

Fig. 2. Freight traffic: external costs pro tonne kilometer in 2010 (Ecoplan, Infras 2014).



Furthermore these external costs have been defined for various types of heavy vehicles as follows: The total external costs of heavy vehicles that are paying the fee are CHF 1’293 Mio. These costs are partially recovered by the LSVA in the amount of 720 Mio CHF. This means that the remaining CHF 573 Mio are not recovered of which the freight trucks (Lastwagen) bear 65%, articulated and semi-trucks (Sattelzuge) 24% and buses (Gesellschaftswagen) 11%.

5. Data quality

An important part of the Ecovehicle project is related to data collected from heavy vehicles. Using data in developing any kind of bonus/malus scheme depend greatly on the quality of the data. One of the important data sets used in the project is weight-in-motion (WIM) data providing axle loads and gross weights as well as other parameters of passing vehicles in real time. Such data is important in considering damage to infrastructure and its source in applying the user pays principle. The quality (accuracy, reliability and stability) of the measurement data used in any study directly determines the quality of the results and conclusions of the study (van Loo et al, 2015). The WIM data from different European countries used in the Footprint project (Poulikakos et al, 2009) have shown variability that could not be explained by mere differences in the national loading regulations alone or road surface properties. The differences in the data may have originated from variations in the local traffic flow, the environmental conditions or from differences in performance of the WIM systems. For a realistic comparison of the environmental impact of different vehicles – and in fact any other study on the impact of heavy truck traffic - the quality of the WIM data must be verified. This is especially important when comparing the effects in different European countries since the measurement data will come from different WIM systems based on different technologies, operating under different conditions and owned by different users.

At present there is no uniform European standard procedure to make an assessment of the quality of WIM data from different systems. As a result many studies are based on WIM data with little - if any - idea of the quality of the data and as a consequence some conclusions may be based on erroneous data. A full guarantee of the quality of WIM data can only be given after an extensive evaluation of the performance of the WIM system, the traffic and environmental conditions over a long period of time (e.g. 1 year, or even longer). In most cases, such an extensive evaluation is too time consuming, too expensive to carry out and also too complicated since it requires an in depth knowledge of WIM systems and sensor behavior. A limited and simplified evaluation could fill the gap between an extensive and expensive test and no test at all, allowing for a quick assessment of the quality of the WIM data.

The key aspects of ensuring good data quality is finding the right tests and criteria to adequately assess the data. In other words this means finding characteristics of certain types of vehicles that show a very small variation in daily practice and are commonly found throughout Europe. This can either be caused by international regulations for heavy goods vehicles or by standards in vehicle design.

The following tests were suggested, after analysis, as being adequate bench marks for heavy goods road vehicles in Europe (van Loo et al, 2015);

1. The vehicle length of Truck+Trailer combinations and that of Tractor+Semi-trailer (articulated) combinations. For most EU member states the maximum allowable lengths for these combination are respectively 18.75m and 16.50m;
2. The Gross Vehicle Weight (GVW) of 3 axle Trucks and that of 5 axle Tractor + Semi-trailer (articulated) combinations. For most EU member states the maximum allowable GVW’s for these combination are respectively 26ton and 40/44ton;
3. The axle load of the first (steering) axle of – fully loaded - 5 and 6 axle articulated vehicles. International experience has shown that the load on this axle lies normally in a narrow bandwidth between 6.5 and 7.0 tonnes;
4. The axle distance between the 2nd and 3rd (driven) axles of 6 axle Tractor + Semi-trailer combinations. International experience has shown that the distance between these axles is very stable at 1.30m as this allows the highest axle loads;

Although the data quality test above refer to parameters directly related to heavy road goods vehicles, similar tests could not be applied to rail vehicles by identifying common traits amongst wagons, locomotives etc.

For these tests, the average values and standard deviation can be calculated. The average value can be compared with a reference value to check for the absolute quality, the standard deviation gives a value for the stability of the measurements.

Furthermore, these tests can be used to compare the relative quality of different WIM sites (the quality of the data from site A is better than that of site B) and to give an indication of the absolute quality of the data of a particular site (the data from site C has a quality that is sufficient). However, it should be stressed that the quality of the data is not necessarily technology dependent, it can be seriously affected by the management quality of the WIM systems and the level of scrutiny applied to the data when retrieved.

The outcomes of the tests are sensitive to the choice of which week of data is used. The selected weeks should represent normal operational conditions, variations due to holidays; road or rail works or extreme weather conditions should be avoided.

6. Options to reduce dynamic load

As discussed earlier, road damage is primarily caused by axle loads of heavy vehicles. These axle loads can be measured in situ using WIM sensors. All European countries have allowable limits for axle loads and gross vehicle mass. In situ measurements in Switzerland has shown that the majority of vehicles are within allowable limits (Poulikakos et al 2010), however, there is a small but significant number of vehicles that are overloaded causing most of the damage. Using WIM data for reinforcement is not yet widespread however the data is used for pre selection of overloaded vehicles. The control of overloads is usually done by spot checks by the police. Whereas it is relatively easy to specify axle load and gross vehicle mass limits, it is much more difficult to manage the dynamic loads which result from the interaction between the vehicle and the infrastructure. Road transport managed this 20 years ago through undertaking the research which led to the definition of ‘road friendly’ suspensions though the definition has been written around air suspensions rather than a performance specification. The example from Switzerland shows that with road friendly suspension the double axle loads can be increased from 18 t to 19 t as listed in article 67 of the transport regulations SR 741.11. Hence, firstly recognizing the positive effect of environmentally friendly suspension and secondly providing and incentive for it.

If rail is to carry increasing proportion of traffic as envisaged in various EU white papers then it would be desirable for rail to undertake the research now so that ‘rail friendly’ suspensions could be defined which once adopted could lead to lower track maintenance and high track usage. However the full benefit of lower dynamic forces requires well aligned infrastructures as well as low track force suspensions because they form a coupled system.

7. Options to reduce noise

7.1. Quieter roads

Noise emitted by road vehicles can be split into a contribution of the tyre/pavement interaction (rolling noise) and a contribution of the engine and the exhaust system (propulsion noise). Rolling noise depends mainly on vehicle speed, the number of tires and the tire and pavement properties. The propulsion noise is determined by the configuration of the engine and the exhaust system and by the rotational speed and load of the engine. With the help of emission models such as CNOSSOS (Kephalopoulos 2012), sound radiation by single vehicles can be predicted. Figure 3 shows the speed dependencies of rolling and propulsion noise for passenger cars and heavy vehicles. In general, at low vehicle speeds, propulsion noise dominates while rolling noise is most relevant at higher speeds. As can be seen in Figure 3, the most promising noise abatement strategy in passenger cars is to reduce rolling noise by using low noise tires and the installation of low noise pavements. In case of heavy vehicles, measures that lower propulsion and rolling noise are effective.

With the regulation 1222/2009, the EU introduced in 2012 a label to characterize the properties of individual tires. It displays important information about safety and environmental aspects of a tire. It allows comparing tires in terms of fuel efficiency, wet grip and noise. In order to come up with a statistics of the current truck tire fleet, data of 530 commercially available tires in Central Europe were evaluated (http://www.reifendirekt.ch/LKW-Reifen.html). Heavy vehicle tires are differentiated according to their use as driving axle tires, front axle tires and trailer tires. It was found that on average, driving axle tires are around 3 dB(A) noisier than front axle tires and 5 dB(A) noisier than trailer tires. The span between the 25% and the 75% quantile is generally quite small (2..3 dB(A)), that is to say the majority of the tires in a specific category shows very similar emission values. However in most cases there is a significant difference between the median and the minimum value (4..6 dB(A)). This suggests that a substantial noise reduction potential lies in the suitable choice of the tire.

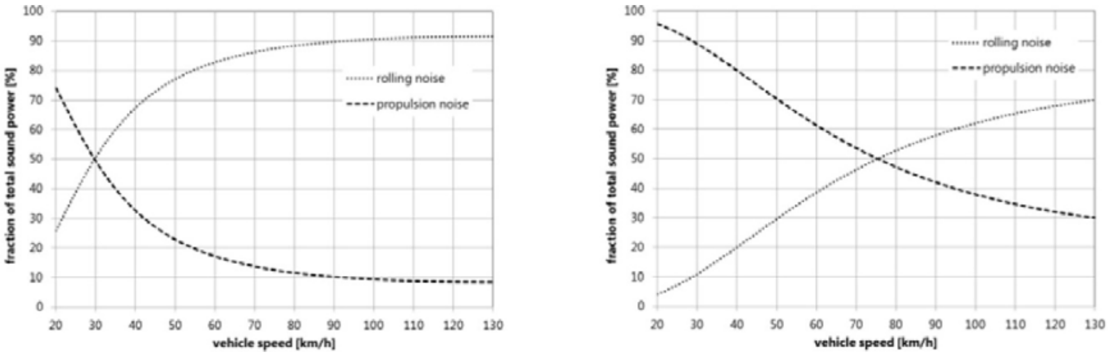


Fig. 3. Rolling noise and propulsion noise as percentage of total noise for passenger cars (left) and heavy vehicles/trucks (right) under reference conditions according to CNOSSOS.

The noise reduction potential of typical low noise pavements compared to standard surfaces is in the order of 3.7 dB(A). This is achieved by optimizing the pavement texture and maximizing the absorption of the pavement by introducing accessible voids with proper shape and length. A third parameter to tune noise emission is the elasticity of the pavement. Recent developments with poroelastic pavements consisting of a significant amount of rubber and bound with an elastic polymer, such as polyurethane, have proven to be capable of reducing the tire/road noise by 8..12 dBA (Goubert 2014).

7.2. Quieter railway lines

Noise from railway lines is composed of rolling noise as a consequence of the interaction of the wheel and the rail, equipment noise (e.g. fans or cooling systems) and aerodynamic noise. At speeds between 40 and 250 km/h, rolling noise is usually the dominant component. Rolling noise is radiated by the vibration of the wheel, the rail and the sleepers. The smoother the wheel and the rail, the lower are the transient forces and thus the excitation. On the vehicle side it is therefore most crucial to keep wheel roughness as low as possible. As braking systems with cast-iron brake blocks introduce strong irregularities on the wheel running surface, they should be replaced by blocks consisting of composite materials or by wheel disk brakes. While wheel disk brakes are standard in passenger coaches, a significant number of freight wagons are still equipped with cast-iron brake systems. A replacement of cast-iron brake blocks with composite materials leads to noise reduction of 8..10 dB(A).

On the side of the infrastructure, rail grinding and rail damping are measures to lower noise emission. While maintenance grinding usually leads to an increase in noise in the first months, acoustic grinding directly aims at lowering the roughness relevant to noise. This type of grinding is done separately from maintenance grinding and is most effective if the wheels of the operating trains are smooth. The more cast-iron brake blocks are replaced by composite materials, the more effective acoustic grinding will become. Rail damping increases the track vibration decay rate. This can be achieved either with rail dampers, products that are applied to the side of the rail, or by changing the track design as such. The noise reduction potential of rail damping is in the order of 2..3 dB(A).

8. Options to reduce pollutant emissions

In burning petrol or diesel, unwanted by-products include CO – toxic, unburnt HC – some of which are carcinogenic or toxic, nitrous oxides – toxic precursor for ozone formation, Particles – some of which are toxic or carcinogenic. Diesel engine technology for the European market has evolved in a series of steps from EURO I to EURO VI which involved treatment of the unwanted by-products including: Diesel oxidation catalysts, particle filtration, selective catalytic reduction and exhaust gas recirculation in some engines. Furthermore, on-board diagnostics were used to ensure that these treatments were effective. Trends in vehicle emissions and increasing exhaust standards had successfully reduced both NOx and PMs by a factor of almost 10 (Fig. 4). The data shows that for heavy goods vehicles, real world and laboratory measured emissions were similar except when the engine was cold i.e. when starting up. This is a concern in urban areas with traffic flow where stop/start driving conditions are encountered. There has been no reduction however in CO_2 emissions. For passenger cars, exhaust standards have lowered NO_x and PMs and also EU regulations have succeeded in reducing CO_2 emissions. So for Switzerland, the outcome is a strong decline in NO_x and HC whilst CO_2 had peaked and would slowly decline.

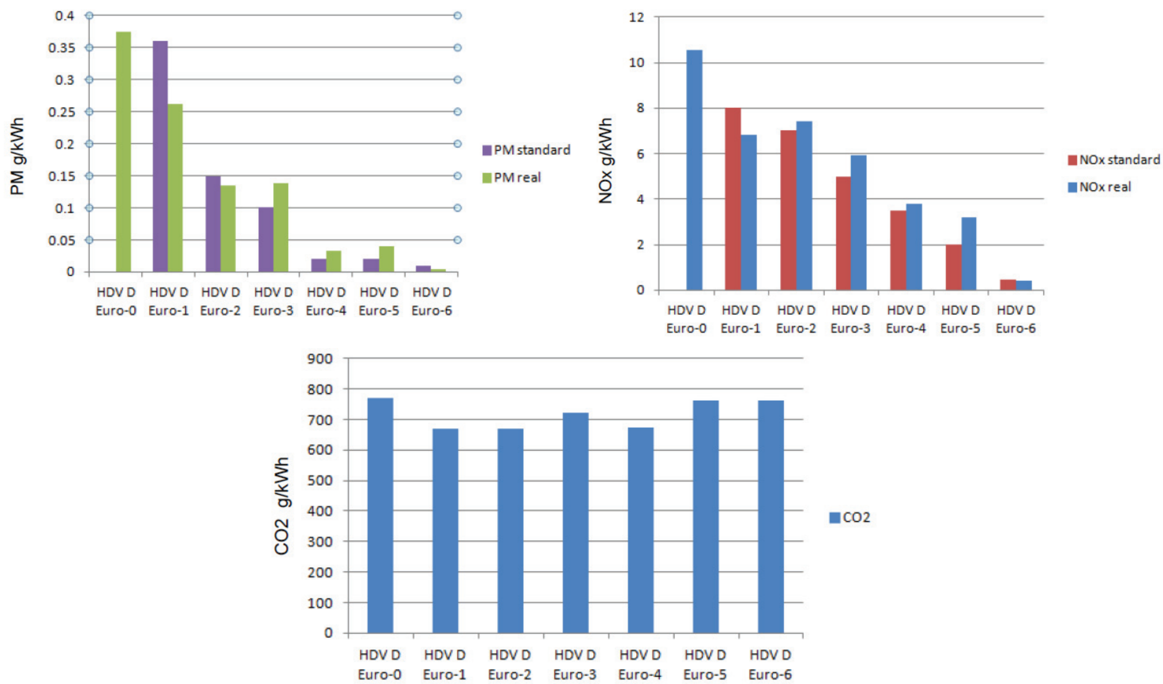


Fig. 4. PM, NOx and CO_2 emissions produced by typical engines for heavy duty vehicles (Harald Jenk 2015).

Beyond EURO VI**,** additional technologies are being investigated, which would increase the overall fuel efficiency of the vehicle from 45% to a target value of 55%, which might be achieved by 2020. This should be possible using integrated energy management including on-board energy storage to reduce fuel consumption in stop/start city traffic. Furthermore, a Low emission strategy is being considered for example by Transport Scotland where steps are being undertaken to introduce low emission zones in Scotland. This was necessary because some areas were in breach of WHO obligations to maintain air quality. Here the primary concern should be linked to health rather than energy or climate change. There has been some progress in decarbonizing the electricity grid in Europe. The increase in renewables has been very significant, driven by a tenfold reduction in the cost of solar PV. By 2020 it was predicted that investment in renewable sources would overtake that of fossil fuels whose share of new generation would continue to decline. The key to balancing the grid demand would be the ability to switch loads of which heat pumps for heating (and cooling) dwellings and recharging batteries of electric vehicles would become the principal switchable loads. An example of a new type of frequency switch would be trialed on Fair Isle, an isolated community between Shetland and Orkney, who derived their electricity from wind power.

Swiss heavy goods vehicle fee (LSVA) is used to recover the external costs (and benefits) of heavy good vehicles. Health, noise and climate change accounted for 70% of this cost. For cycling, the external cost exceeded the external benefit while for walking the reverse applied. The reduction of 10% in HGV fee for EURO VI equipped trucks had been dramatic and the percentage of vehicles equipped with such engines now exceeded 90% of the transit traffic.

9. Summary and conclusions

With increasing traffic the external costs of transport are on the rise. A combination of better technology and incentives for operators to introduce such technology could presumably reduce the impact of heavy vehicles. This should be done on a European level in order to accelerate the introduction of a sustainable European transportation system.

Heavy vehicle data analyzed during this project has shed some light on the sources of environmental footprints of HGVs. The data has shown that there is a small but significant number of vehicles, road as well as rail, that are overloaded or their suspension is faulty or their wheels (for rail vehicles) are out of round, which cause a high proportion of damage to the infrastructure and environment. Considering the total footprint of vehicles obtained by combining weight, noise and pollutant emissions data it was seen that in almost every Swiss category there are vehicles that have a high total footprint demonstrating the potential for improvement.

In the on-going discussion on the adaptation of longer and heavier vehicles for road freight transport in order to increase the transport capacity, the vehicle infrastructure interaction should be taken into account. As the vehicle suspension and infrastructure form a coupled system, the resulting dynamic interaction can only be reduced by encouraging good design of both constituents. With the ever increasing desire to move people and goods, the need to incentivize good design becomes ever more necessary.

Noise monitoring has shown that the EURO V category vehicles that are environmentally friendly regarding their engines are not necessarily environmentally friendly with respect to noise emissions. Europe wide policies should be placed in order to encourage vehicles with a low total footprint that includes noise emissions. The data from Switzerland shows that the available instruments are not sufficient and new instruments have to be developed in order to encourage vehicles with a low noise footprint.

Directive 1999/62/EC of the European Commission is in place for harmonization of levy systems and fair mechanisms for charging for infrastructure costs in order to eliminate distortions of competition between transporters in member states (EC DIR 1999). It is explicitly stated in this directive that minimum rates should be set for vehicle taxes and that road-friendly and less polluting vehicles should be encouraged through differentiation of taxes or charges. Below are some excerpts that are relevant in the framework of the current discussion:

“Charges should be based on duration of use of infrastructure; Member states should be able to attribute to environmental protection a percent of the user charge; Costs of infrastructure or infrastructure improvements may include any specific expenditure on infrastructure designed to reduce nuisance related to noise; ‘external-cost charge’ means a charge levied for the purpose of recovering the costs incurred in a Member State related to traffic-based air pollution and/or traffic-based noise pollution;‘cost of traffic-based air pollution’ means the cost of the damage caused by the release of particulate matter and of ozone precursors, such as nitrogen oxide and volatile organic compounds, in the course of the operation of a vehicle;‘cost of traffic-based noise pollution’ means the cost of the damage caused by the noise emitted by the vehicles or created by their interaction with the road surface; the member states may establish differentiated noise charges to reward the use of quieter vehicles”.

Furthermore, a recent report by the World Health organization (WHO) indicates that in the EU and Norway, traffic noise is the second biggest environmental problem affecting health after air pollution. This new health evidence highlights the urgency of adopting more stringent EU vehicle noise standards. Further evidence by WHO indicate that noise can disturb sleep, cause cardiovascular and psychophysiological effects, reduce performance and provoke annoyance responses and changes in social behavior. Traffic noise alone is harming the health of almost every third person in the WHO European Region. One in five Europeans is regularly exposed to sound levels at night that could significantly damage health (WHO 2012).

Incentives versus regulation – do we need both?

The work in the Ecovehicle project has shown that incentive followed subsequently by regulation might be an optimal solution; also that incentives could be provided by environmental taxes provided that this did not disadvantage any one mode. The differential charging scheme successfully implemented by the Swiss heavy vehicle fee, the LSVA is a bonus/malus system based on the gaseous emissions of vehicles and therefore will not be effective in the longer term in encouraging vehicles with a low total environmental footprint as the updated vehicle fleet is mostly Euro-V which was shown is not necessarily less noisy. As discussed above, noise from road traffic incur significant external costs, these costs are well recovered by the Heavy vehicle fee, but – since noise is not a criteria in the charging scheme – there is no incentive to purchase less noisy vehicles.

In-situ measurements the most effective way of enforcement

The consensus in the project is that self-declaration followed by spot checks involving pre-selection was the most effective method to deliver the needed parameters to define environmental footprint of vehicles. Data quality is of particular importance when comparing the environmental effects in different European countries. This becomes even more important when bonus/malus schemes were to be based on collected data.

Should transit countries cooperate to minimize noise reduction?

This is highly desirable in order to prevent transit traffic moving routes to countries with low environmental taxes. It would also accelerate introduction of low noise technology.

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